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**van Gemert et al.**

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(54) **DIE INTERCONNECT**

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(71) Applicant: **NXP B.V.**, Eindhoven (NL)  
(72) Inventors: **Leonardus Antonius Elisabeth van Gemert**, Nijmegen (NL); **Coenraad Cornelis Tak**, Waalre (NL); **Marten Oldsen**, Kleve (DE); **Hendrik Bouman**, Nijmegen (NL)  
(73) Assignee: **NXP, B.V.**, Eindhoven (NL)  
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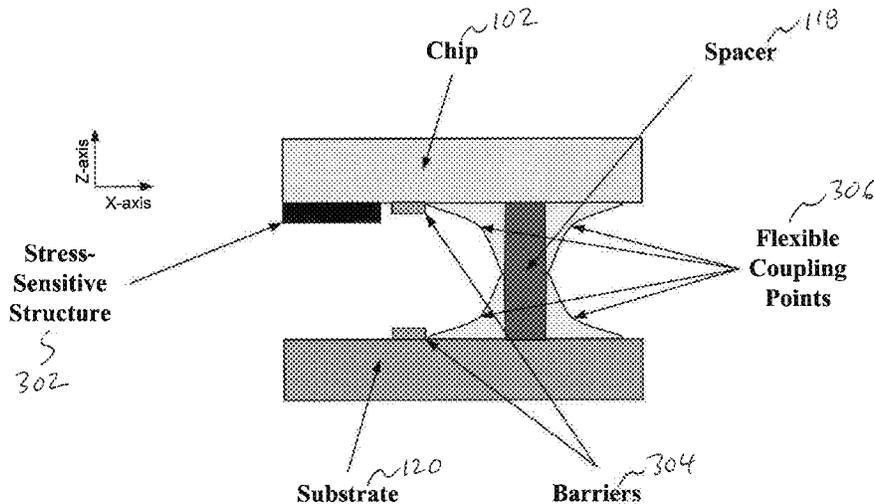
(51) **Int. Cl.**  
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**H01L 23/66** (2006.01)  
**H01L 23/58** (2006.01)  
**H01L 23/00** (2006.01)  
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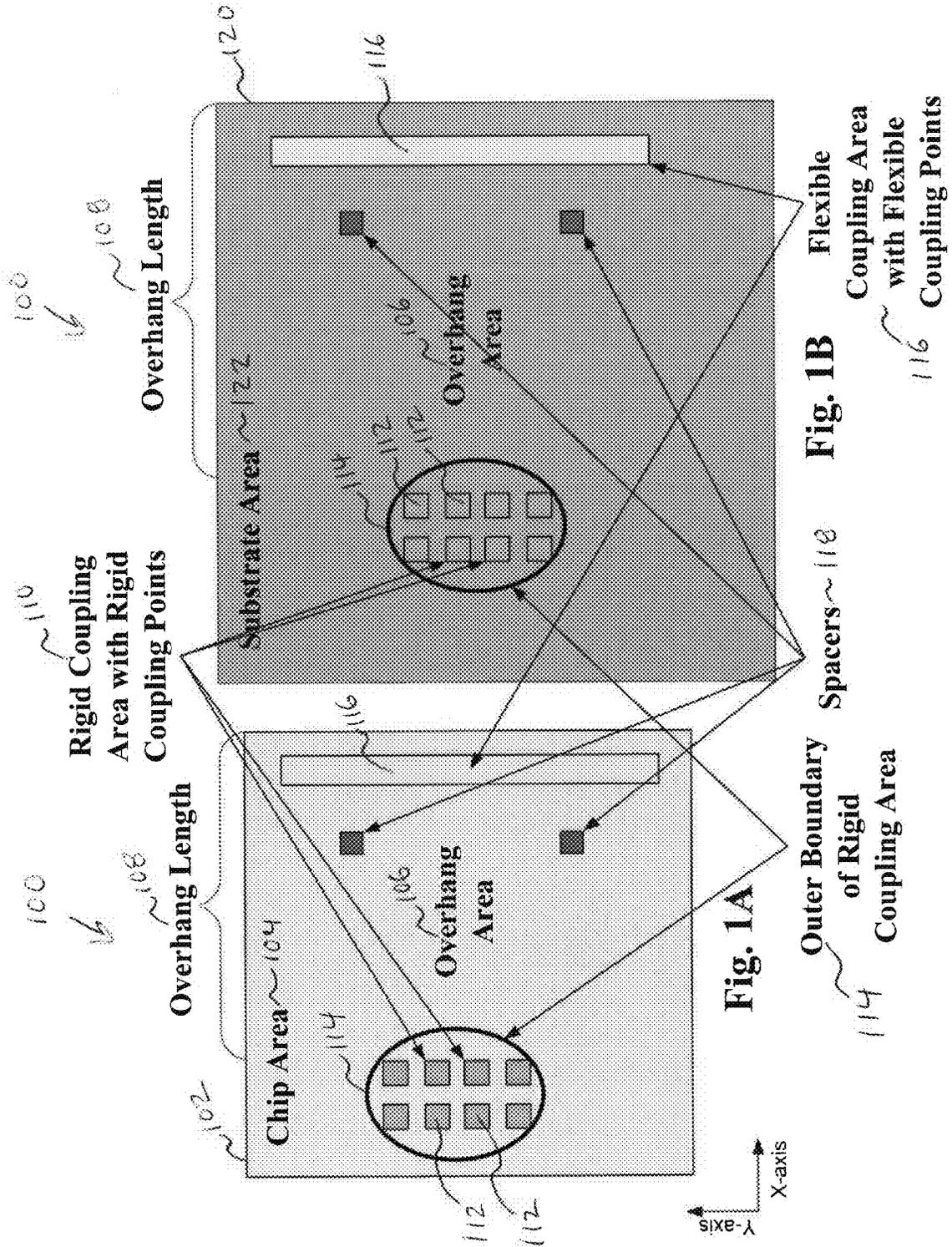
(57) **ABSTRACT**  
One example embodiment discloses a chip having a chip area, wherein the chip area includes: an overhang area; a rigid coupling area, having a set of rigid coupling points, located on one side of the overhang area; and a flexible coupling area, having a set of flexible coupling points, located on a side of the overhang area opposite to the a rigid coupling area. Another example embodiment discloses a method for fabricating a die interconnect, comprising: fabricating a rigid coupler area, having a set of rigid coupler points, within a chip having a chip area; defining an overhang area within the chip area and abutted to the rigid coupler area; and fabricating a flexible coupler area, having a set of flexible coupler points, within the chip area abutted to a side of the overhang area opposite to the rigid coupler area.

(52) **U.S. Cl.**  
CPC ..... **H01L 24/17** (2013.01); **B81B 7/007** (2013.01); **B81B 7/0048** (2013.01); **H01L 24/11** (2013.01); **H01L 24/14** (2013.01); **H01L 2224/1401** (2013.01); **H01L 2224/1701** (2013.01); **H01L 2924/35** (2013.01)

(58) **Field of Classification Search**  
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USPC ..... 257/737, 202; 438/613  
See application file for complete search history.

**14 Claims, 5 Drawing Sheets**





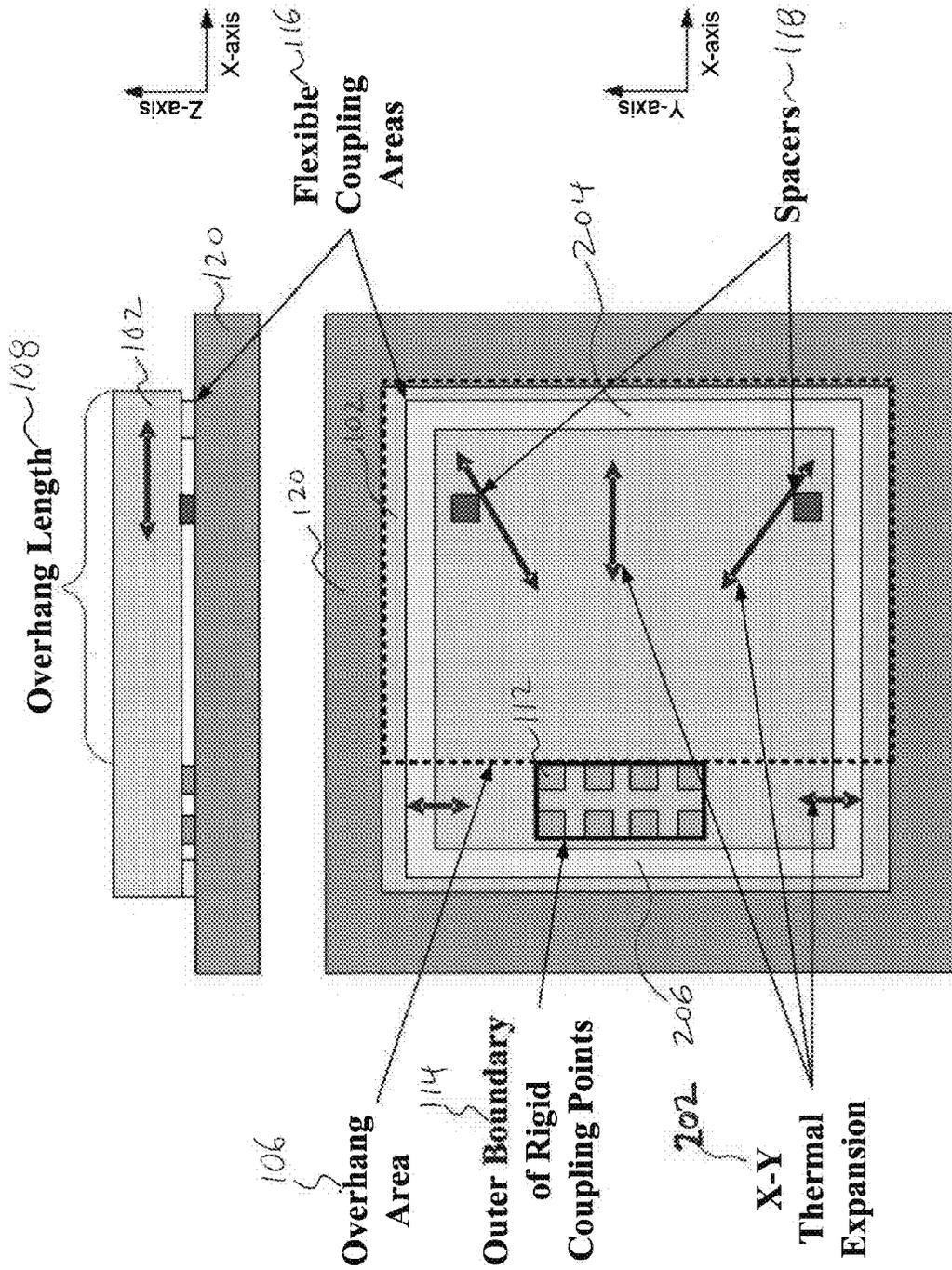


Fig. 2

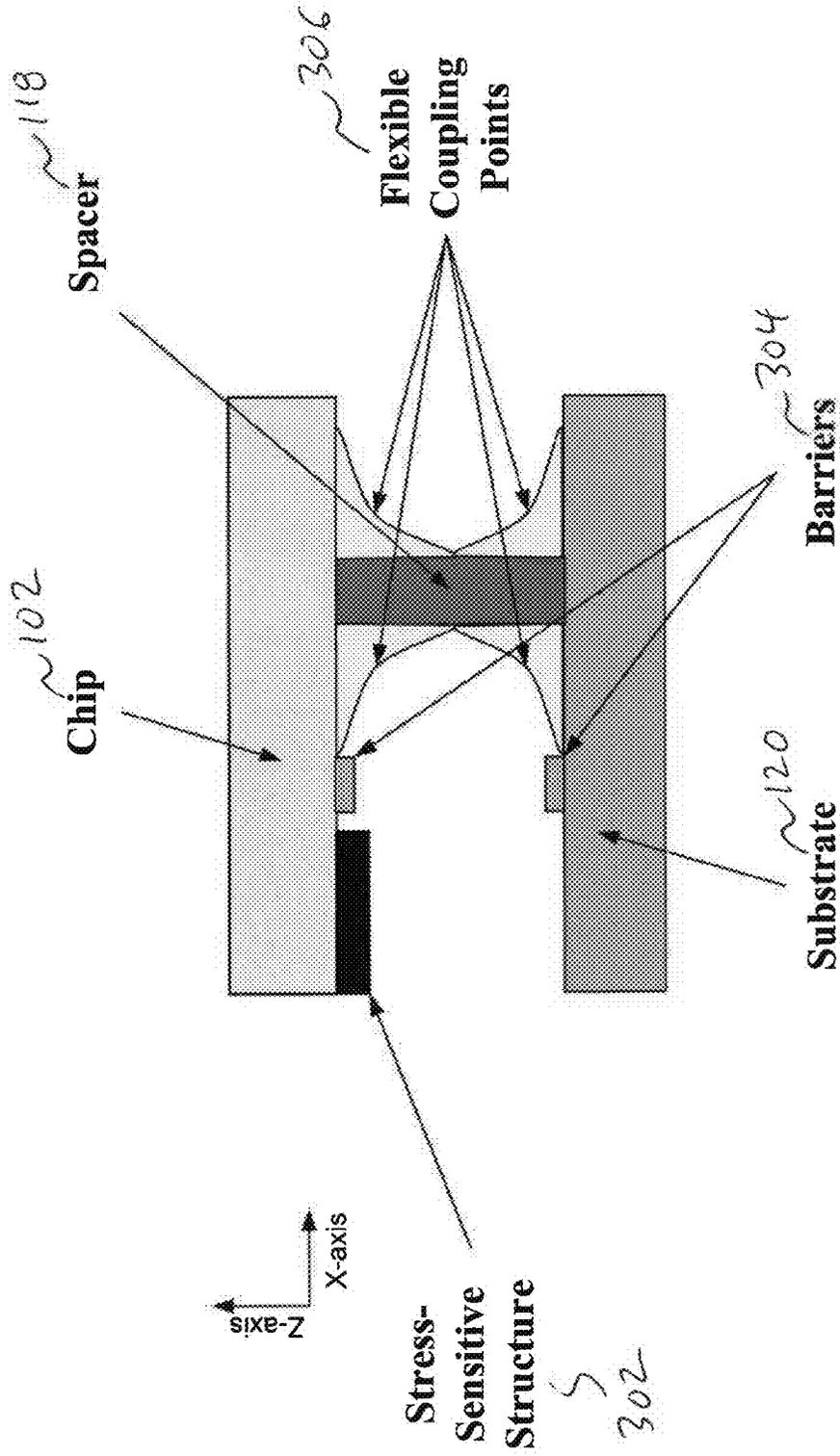


Fig. 3

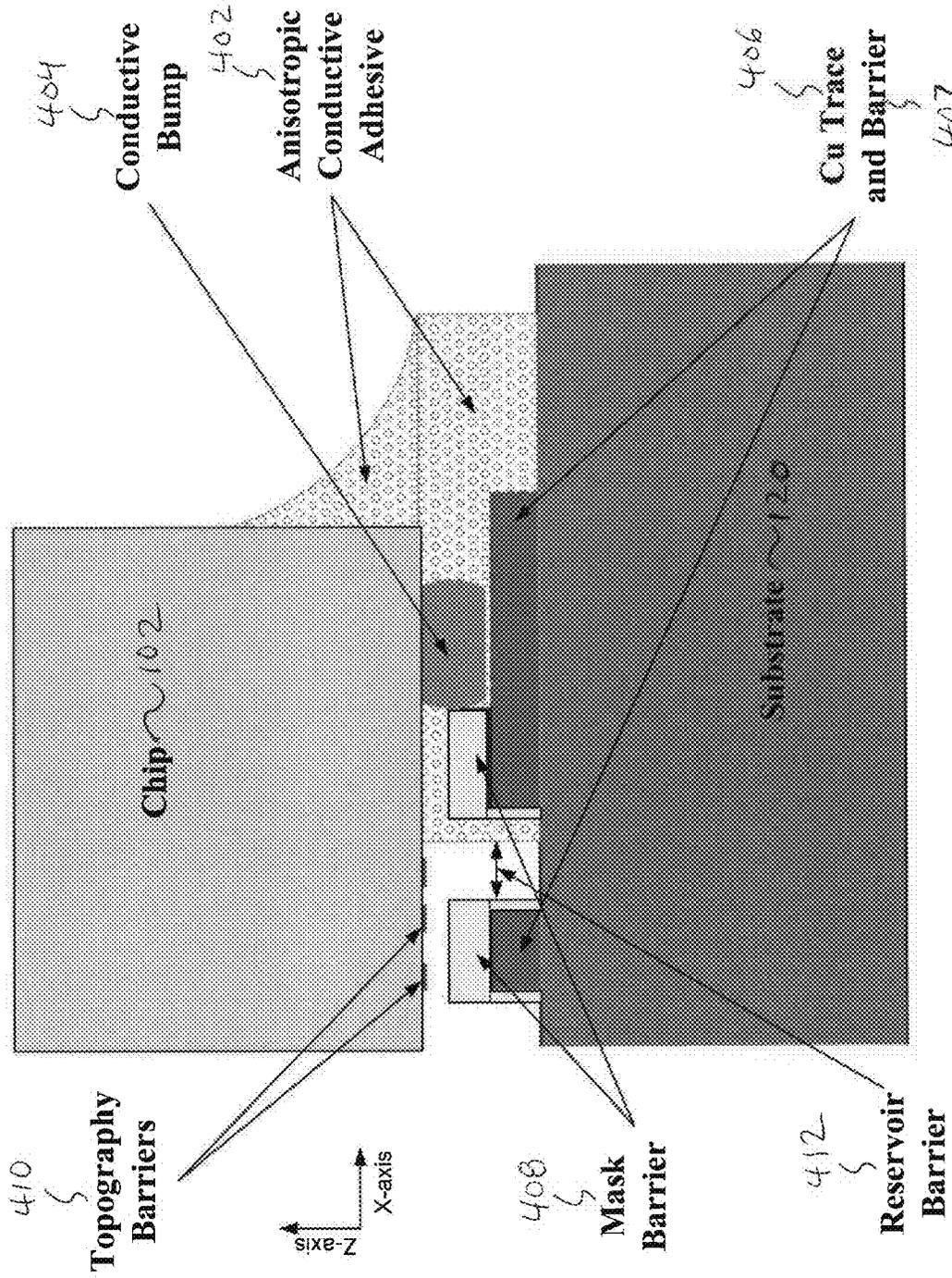
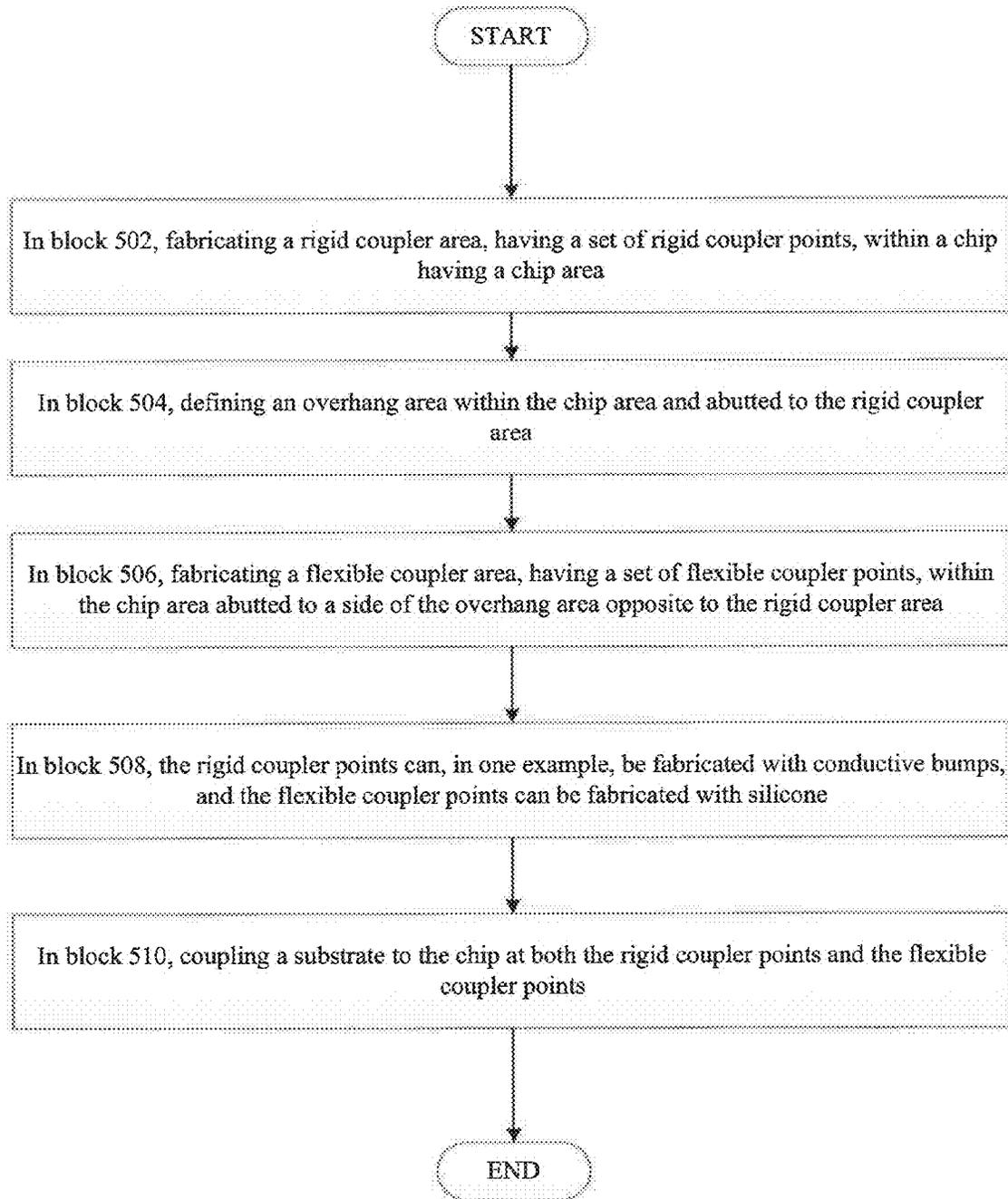


Fig. 4



**Fig. 5**

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**DIE INTERCONNECT**

## BACKGROUND

## Brief Background Introduction

This specification relates generally to device attachments and in one example to a die interconnect.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A shows one example of a die interconnect on a chip.

FIG. 1B shows one example of a die interconnect on a substrate.

FIG. 2 shows one example of a die interconnect between a chip and a substrate.

FIG. 3 shows one example of a flexible coupling point within a die interconnect.

FIG. 4 shows one example of a rigid coupling point within a die interconnect.

FIG. 5 lists one example of a method for fabricating a die interconnect.

While the disclosure is amenable to various modifications and alternative forms, specifics thereof have been shown by way of example in the drawings and will be described in detail. It should be understood, however, that other embodiments, beyond the particular embodiments described, are possible as well. All modifications, equivalents, and alternative embodiments falling within the spirit and scope of the appended claims are covered as well.

## DETAILED DESCRIPTION

Semiconductor devices whose input/output (IO) pins are spread out over the chip surface can result in a very stiff connection between a chip and substrate such that thermal mismatch between chip and substrate results in chip stresses.

Semiconductor devices include sensors (e.g. pressure sensors). Such sensors, dependent on the design, are sensitive to stress on an Si die (e.g. a silicon chip) which will affect the sensor's sensitivity and accuracy.

Stress on Si sensor chip can be generated when materials with different thermo-mechanical properties are connected together. This stress is an effect of a difference in coefficients of thermal expansion (CTE) and in combination with the modulus of the material, leads to stresses. Temperature changes in this case lead to a variation in stress. Also Humidity variations can lead to stress variations especially when organic materials are used. The chip itself can generally cope with these stresses but the sensor which is processed on the chip surface will be affected by minimal amounts of stress change. Also when organic materials or metals are used variation in stress (e.g. relaxation) over time can happen due to creep effects of these materials. As some Si sensors are used for absolute measurements stress variation over time could create inaccurate sensor signals.

Mounting the Si chip on a substrate with similar coefficients of thermal expansion may not always result in the best or most economical solution. Other alternatives using wire-bonds and flexible glues in pre-molded or cavity packages can lead to increase in size and cost.

In one example embodiment discussed in more detail below, chip stress is minimized by fixing the chip on one relatively small area, using flip chip interconnect, thereby letting the chip freely expand in all directions. Flip chip in general is a very stiff construction not allowing for stress relief but by using a small area with fine pitch interconnect-

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tions between chip and substrate the stress is minimal and localized in that small area. The rest of the chip remains stress free. By grouping all interconnects on a small area, the mismatch in thermal expansion is reduced and thus the absolute stress is reduced (small distance), so that the remainder of the chip remains free from stress including a sensor area.

With the contact between the Si chip and the carrier substrate minimized, the majority of the chip is free to expand and contract due to temperature variations without building up stress on not contacted areas. The area which is in contact with the carrier substrate is kept minimal. This set of rigid coupling points can be located at various chip locations and be arranged in different patterns. In such embodiments, the stress build up increases with the dimension of the contact. The smaller this contact the smaller the stress. An area which is sensitive for the stress can be on a different location on the Si chip.

Details of the present claimed device/service are now discussed.

FIG. 1A shows one example of a die interconnect **100** on a chip **102**. FIG. 1B shows one example of the die interconnect **100** on a substrate **120**. Thus the die interconnect **100** can be first fabricated on either the chip **102** or the substrate **120** before the chip **102** and substrate **120** are connected together by the die interconnect **100** thereby forming a package. Chip and die are used interchangeably in this specification and refer to a circuit element or a collection of circuit elements.

The die interconnect **100** includes the chip **102** having a chip area **104**, or alternately the substrate **120** having a substrate area **122**. The chip and substrate areas **104**, **122** include an overhang area **106**, a rigid coupling area **110** and a flexible coupling area **116**. The rigid coupling area **110** includes a set of rigid coupling points **112**, located on one side of the overhang area **106**. The flexible coupling area **116**, includes a set of flexible coupling points **306**, located on a side of the overhang area **106** opposite to the rigid coupling area **110**. In one example, the rigid coupling points **112** are electrical coupling points and the flexible coupling points **306** are mechanical coupling points.

In an example embodiment, the rigid coupling points **112** are formed from anisotropic conductive adhesive (ACA) glue. When placed between two closely spaced metal surfaces, the ACA glue shrinks when cured and silver particles within the ACA create an electrical contact between the two metal surfaces. ACA glue does not conduct in the x-y axis directions. ACA glue may be deposited on the chip **102** or substrate **120** using either a lamination, dispense or screen printing process.

In another example embodiment, the ACA glue is replaced by rigid solder bumps, copper (Cu) stud-bumps or a wire bond. Use of ACA glue however enables a pitch (i.e. distance) between the electrical contacts to be smaller than solder connections would permit. The ACA glue can also be replaced by a NCA (Non Conductive Adhesive) along with Cu stud bumps having an Sn cap that allows soldering on to the substrate. Pitch using the NCA-type interconnect may be low as well. In other examples, the ACA glue can be applied in the shape of an anisotropic conductive paste (ACP) or in the shape of anisotropic conductive foil (ACF)

The flexible coupling points in the flexible coupling area **116**, in one example, are formed from a soft flexible, non-conductive, glue which flexes along x-y-z axes to avoid stress build-up. Glues from the silicone family of glues that permit in plane movement can be used in this flexible coupling area.

In an example embodiment, a set of spacers **118** are located within either the overhang area **106** or the flexible coupling area **116**. The spacers **118** prevent tilting during the package

assembly process and help ensure a relatively constant gap between the Si chip **102** and the substrate **120**. These spacers **118** can be either filler particles in a soft glue or additional bumps similar to the ones which form the rigid or flexible coupling points. In one example, the spacer bumps **118** are fixed to the chip **102** but not to the substrate **120** and thus can slide over the substrate **120** without adding stress to the chip **102**.

The rigid coupling area **110** is within an outer boundary **114** and the flexible coupling area **116** and overhang area **106** are outside of the outer boundary **114**. In one example, the outer boundary **114** encloses up to 50% of the chip area **104**. In another example, the chip or substrate area **104**, **122** is defined by a x-axis length and a y-axis width, and the overhang area **106** has an x-axis overhang length **108** which is at least 50% of the chip or substrate area's **104** or **122** x-axis length. However in other examples, the % overlap can range from 1% to 99%.

In different example embodiments, the substrate **120** could be a second chip, a circuit board or glass.

FIG. **2** is one example of a die interconnect **100** between a chip **102** and a substrate **120**. In this example the chip **102** has already been connected to the substrate **120** using the die interconnect **100** thereby forming a package. For clarity, in the x-y view of the package of FIG. **2** the chip **102** is transparent so that the die interconnect **100** can be seen. FIG. **2** shows an example of how the chip **102** can be fixed to a substrate **120** on only a small area. As such the stress build up between the Si chip **102** and substrate **120** is minimized.

The chip **102** is coupled to the substrate **120** with the set of rigid **112** and flexible coupling points in the flexible coupling area **116**. As shown in FIG. **2**, the flexible coupling area **116** can be on a side of the overhang area **106** opposite to **204** the rigid coupling points **112**. Alternatively, the flexible coupling area **116** can be adjacent to **206** the rigid coupling points **112** and on a same side of the overhang area **106** as the rigid coupling points **112**. Several options for connecting the chip **102** to the substrate **120** are possible.

In one example both the conductive ACA glue and the non-conductive silicone glue are applied to the chip **102** or substrate **120**. The chip **102** is then placed in position over the substrate **120** and the two are pressed together to mount the chip **102** to the substrate **120**.

In another example, the conductive ACA glue is applied to the chip **102** or substrate **120**, the chip **102** and substrate **120** are connected, the ACA glue is cured and then a fillet of silicone glue is placed around the outside edge of the chip **102** and onto the substrate **120** below and the silicone is cured.

FIG. **2** also shows an example of how the optional spacer bump **118** keeps the chip **102** and substrate **120** at a relatively constant distance. After the chip and substrate are coupled, an additional fillet of the flexible glue can also be applied around the or on several points to further fix the chip. After curing the substrate array can be cut into individual packages using chip singulation, punching or other separation technique. Optionally a cap could be placed over the chip (e.g. Si chip) for mechanical protection.

With the rigid coupling points **112** localized on the chip **102** x-y thermal expansion **202** can more easily be accommodated resulting in less chip **102** stress.

FIG. **3** is one example of a flexible coupling point **306** within a die interconnect **100**. In this example the spacer **118** is included in the flexible coupling area **116** to prevent tilting of the chip. The spacer **118** is surrounded with a flexible glue such as silicone. As can be seen, the glue can flow out toward a stress-sensitive structure **302** located in the overhang area **106**.

Since glue contact with the stress-sensitive structure **302** might affect proper functioning of the structure **302**, a set of barriers **304** are affixed to both the chip **102** and the substrate **120**. In another example, the barrier **304** is inserted between a portion of the chip or substrate areas **104**, **122** and either the rigid coupling area **110** or the flexible coupling area **116**.

In various example embodiments, the barrier **304** can be formed from: a dam, a reservoir, a topography, a mask, a copper trace with a barrier mask, a polyimide coating, or a passivation layer.

Note that the stress-sensitive structure **302** can include a variety of structures which may be sensitive to stress, such as: a mechanical device, an electrical device, a sensor (e.g. pressure or otherwise), a functional electrical block, an electrical component (e.g. a resistor, a capacitor, etc.) and/or a functional parameter.

FIG. **4** is one example of a rigid coupling point **112** within a die interconnect. The rigid coupling point **112** includes an anisotropic conductive adhesive (ACA) **402**, a conductive bump **404**, and a copper (Cu) trace **406**. The conductive bump **404** electrically coupled to the chip **102** and the copper trace **406** is mechanically coupled to the substrate **120**. The ACA glue **402** flows between the conductive bump **404** and the copper trace **406** forming an electrical coupling after cure. The copper trace **406** includes a barrier **407** which can be copper or another substance. In FIG. **4** the barrier **407** is also formed from the copper trace **406**. The barrier **407** helps prevent flow-out of the ACA glue **402** before the glue is cured. Other barriers to the ACA **402** glue include: a mask barrier **408**, a topography barrier **410**, and a reservoir barrier **412**. As mentioned above, the ACA glue can be applied in the shape of an anisotropic conductive paste (ACP) or in the shape of anisotropic conductive foil (ACF).

FIG. **5** lists one example of a method **500** for fabricating a die interconnect. The method **500** begins in block **502**, by fabricating a rigid coupler area, having a set of rigid coupler points, within a chip having a chip area. In block **504**, defining an overhang area within the chip area and abutted to the rigid coupler area. Then in block **506**, fabricating a flexible coupler area, having a set of flexible coupler points, within the chip area abutted to a side of the overhang area opposite to the rigid coupler area. In block **508**, the rigid coupler points can, in one example, be fabricated with conductive bumps, and the flexible coupler points can be fabricated with silicone. Then in block **510**, a substrate is coupled to the chip at both the rigid coupler points and the flexible coupler points.

The blocks comprising the flowcharts in the above Figures can be executed in any order, unless a specific order is explicitly stated. Also, those skilled in the art will recognize that while one example method embodiment is now discussed, the material in this specification can be combined in a variety of ways to yield other examples as well. The method next discussed is to be understood within a context provided by this and other portions of this detailed description.

Example embodiments discussed in this specification can be implemented in whole or in part within a variety of electronic, and non-electronic devices, apparatus, systems and structures.

In this specification, example embodiments have been presented in terms of a selected set of details. However, a person of ordinary skill in the art would understand that many other example embodiments may be practiced which include a different selected set of these details. It is intended that the following claims cover all possible example embodiments.

What is claimed is:

1. Die interconnect, comprising:

a rigid chip having a chip area, a first side and a second side, wherein the chip area includes:

a contiguous overhang area on the first side of the chip;

a contiguous rigid coupling area on the first side of the chip, having a set of rigid coupling points located on a first lateral side of the overhang area; and

a contiguous flexible coupling area also on the first side of the chip, having a set of flexible coupling points located on a second lateral side of the overhang area opposite to the rigid coupling area located on the first lateral side;

wherein the rigid chip is configured to be coupled to a substrate on the first side of the chip by the rigid and flexible coupling areas;

wherein the rigid coupling points are electrical coupling points; and

wherein the flexible coupling points are mechanical, but not electrical, coupling points.

2. The interconnect of claim 1, further comprising:

a set of spacers located within either the overhang area or the flexible coupling area.

3. The interconnect of claim 1, wherein:

the rigid coupling area is within an outer boundary; and the flexible coupling area and overhang area are outside of the outer boundary.

4. The interconnect of claim 3, wherein the outer boundary encloses up to 50% of the chip area.

5. The interconnect of claim 1, wherein the chip is coupled to the substrate with the set of rigid and flexible coupling points.

6. The interconnect of claim 5, wherein the substrate includes at least one from a group consisting of: a second chip; a circuit board, ceramic substrate and glass.

7. The interconnect of claim 1:

wherein the chip includes a stress-sensitive structure located in the overhang area; and

wherein the stress-sensitive structure includes at least one from a group consisting of: a mechanical device, an

electrical device, a sensor, a functional electrical block, an electrical component and a functional parameter.

8. The interconnect of claim 1, wherein the rigid coupling points include at least one from a group consisting of: an anisotropic conductive adhesive and a conductive bump.

9. The interconnect of claim 1, wherein the flexible coupling points include a silicone glue.

10. The interconnect of claim 1, further comprising: a barrier between a portion of the chip area and either the rigid coupling area or the flexible coupling area.

11. The interconnect of claim 10, wherein the barrier is at least one from a group consisting of: a dam, a reservoir, a topography, a mask, and PI.

12. A method for fabricating a die interconnect, comprising:

fabricating a contiguous rigid coupler area, having a set of rigid coupler points, on a first side of a rigid chip having also a second side opposite to the first side;

defining a contiguous overhang area on the first side within the chip area and abutted to the rigid coupler area;

fabricating a contiguous flexible coupler area, having a set of flexible coupler points, within the chip area, located on a second lateral side of the overhang area opposite to the rigid coupler area located on a first lateral side; and

wherein the rigid coupler points are electrical coupler points; and

wherein the flexible coupler points are mechanical, but not electrical, coupler points.

13. The method of claim 12, further comprising: coupling a substrate to the chip at both the rigid coupler points and the flexible coupler points.

14. The method of claim 12, further comprising: fabricating the rigid coupler points with at least one from a group consisting of: anisotropic conductive adhesive, anisotropic conductive film and anisotropic conductive paste; and

fabricating the flexible coupler points with silicone.

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